TECH ENGINEERING NEWS

NOVEMBER · 1942

Information supplied by "Mechanical Engineering"

There exists a very evident need for the correlation of available data on mechanical springs, and for the formulation of a standard code for the design of helical springs. As a result, a group of specialists have made suggestions in a symposium, published in the July 1942 Transactions of the A.S.M.E. which it is hoped will crystallize into early action.

The scope of a proposed code, design stresses, the arrangement and scope of helical spring tables, the advantages and disadvantages of nomographic charts, and the future research needed on mechanical spring problems are all discussed in the symposium.

Serious attention to the problem of mechanical spring design began in 1924 with the establishment of the A.S.M.E. Research Committee on Mechanical Springs. Since that date, 66 papers on the subject have appeared in various A.S.M.E. publications. They have laid the groundwork for a design code which, when completed and adopted, should simplify the work of designers. The symposium contains a bibliography.

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TECH ENGINEERING NEWS

NOVEMBER · 1942

VOLUME XXIII

NUMBER 6

COVER

General view, turbine gallery, Nevada wing, Boulder Dam. These shafts from the water-wheel turbines (below the floor) drive six 82,500 kva generators which furnish a total of nearly half a million kva for the Pacific Coast's vital power requirements.

Westinghouse Electric and Manufacturing Company

FRONTISPIECE

The output of Navy radio equipment has been stepped up tremendously.

General Electric Company

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THE BETATRON

CYCLOTRON FOR ELECTRONS

By DR. DONALD W. KERST

DEPARTMENT OF PHYSICS, UNIVERSITY OF ILLINOIS

ELECTRONS with speeds differing by less than one-tenth of one per cent from their ultimate speed limit, the velocity of light, now can be produced in moderately sized apparatus and in quantities great enough to make possible new practical applications of electrons. The betatron, as the name indicates, is a device for producing beta particles or high speed electrons, and the physical processes involved in its operations make possible the acceleration of particles in principle to any desired energy, although these energies may be so high that the particle behaves in an extremely relativistic manner. For example, electrons traveling at speeds now attained in the betatron grow heavy; their mass becomes about forty times as great as the mass of an electron at rest, and the space charge influence or repulsion of neighboring electrons in the circular orbit where they gain speed disappears as the velocity of light is approached.

Although the betatron can probably be used to accelerate not only electrons but also the heavy positive ions such as those accelerated in cyclotrons, it is most interesting to use the betatron on electrons. Heretofore it has not been possible to do experiments with electrons with energies greater than 4.5 million electron volts, the energy which can be provided by the Van de Graaff electrostatic generator. The cyclotron, which can accelerate the heavy positive ions to 16.5 million electron volts, cannot handle lightweight electrons because of their relativistic behavior at high energies. The new method of acceleration which is furnished by the betatron now makes possible electron experiments in new high voltage regions.

So far two betatrons have been constructed, and they are shown side by side in the University of Illinois Physics Department in Fig. 1. The small accelerator on the table is the original betatron which produces approximately three million volt electrons and X-rays of an intensity equivalent to the radiation from approximately one gram of radium. Many electrons escape through the glass walls of the vacuum tube in the small betatron, and many more escape through the walls of the vacuum tube in the large 20 million volt betatron.

These 20 million volt electrons are capable of penetrating as far as 10 centimeters in water, and it is the great penetration of electrons of this energy which suggests their practical use in therapy of deeply lying malignant tissue. It is sufficient for the electron beam to penetrate approximately halfway through the human body for this application, and since it is expected that the ionization and consequent damage produced by the 20 million volt electron beam would have a maximum approximately seven or eight centimeters below the surface of the body one can see that this damage can be fairly well localized. The present use of X-rays in deep therapy is made difficult by the fact that the damage produced by X-ray ionization is present not only at the malignant tissue but at both front and back surfaces of the body. In contrast, the ionization due to a 20 or 30 million volt electron beam is entirely lacking at the back of the body.

The betatron is a magnetic device in which the particles to be accelerated are forced into a circular path of fixed radius. This circular orbit links the magnetic flux within the orbit, and since the magnet is operated on alternating current the flux linkage during one-quarter of the cycle increases and produces an electromotive force around the orbit. It is this voltage gain per revolution, which is exactly equivalent to the instantaneous voltage read by a volt-meter connected to a loop of wire placed at the orbit, which is responsible for accelerating electrons to such high energies. Since the electrons are going practically with the velocity of light most of the time that they are being accelerated, the final voltage is equal to the number of revolutions which a particle having the velocity of light would describe multiplied by the time average voltage per turn at the orbit.

In designing the original betatron it was very important to examine the fine details of the motion of an electron in an alternating magnetic field in order to produce successful operation. It is probably the lack of just this detailed description of the electrons' motion which was responsible for the failure of previous efforts to accelerate electrons by the magnetic induction method. The electrons oscillate both axially and radially about their ideal circular orbit. The decrease of the amplitude of these oscillations as the magnetic field increases is responsible for the formation of a stable beam of electrons capable of remaining in the vacuum tube for path lengths as great as several hundred miles. Fig. 2 shows a sketch of the doughnut-shaped vacuum tube with the electron stream leaving the injector, being trapped in a circular orbit, and after acceleration being projected against the target to the back of the injector where X-rays are produced. The electrons are easily directed against this target by expanding the orbit with a surge of flux linking the orbit. This surge is added to the main magnetic field at a time indicated by point B in the graph. The point A indicates the magnetic field at the time when the electrons were started at low energy on their long journey.

X-rays from the betatrons proceed mainly in the direction which the electrons had when they struck the target. This behavior has simplified the problem of protection of the operators since it is merely necessary for them to stand out of the beam at the back or side of

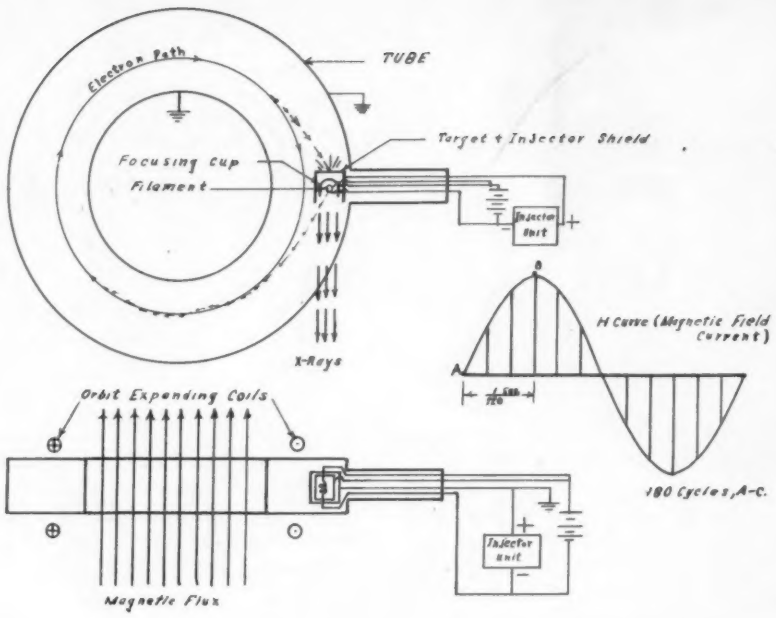


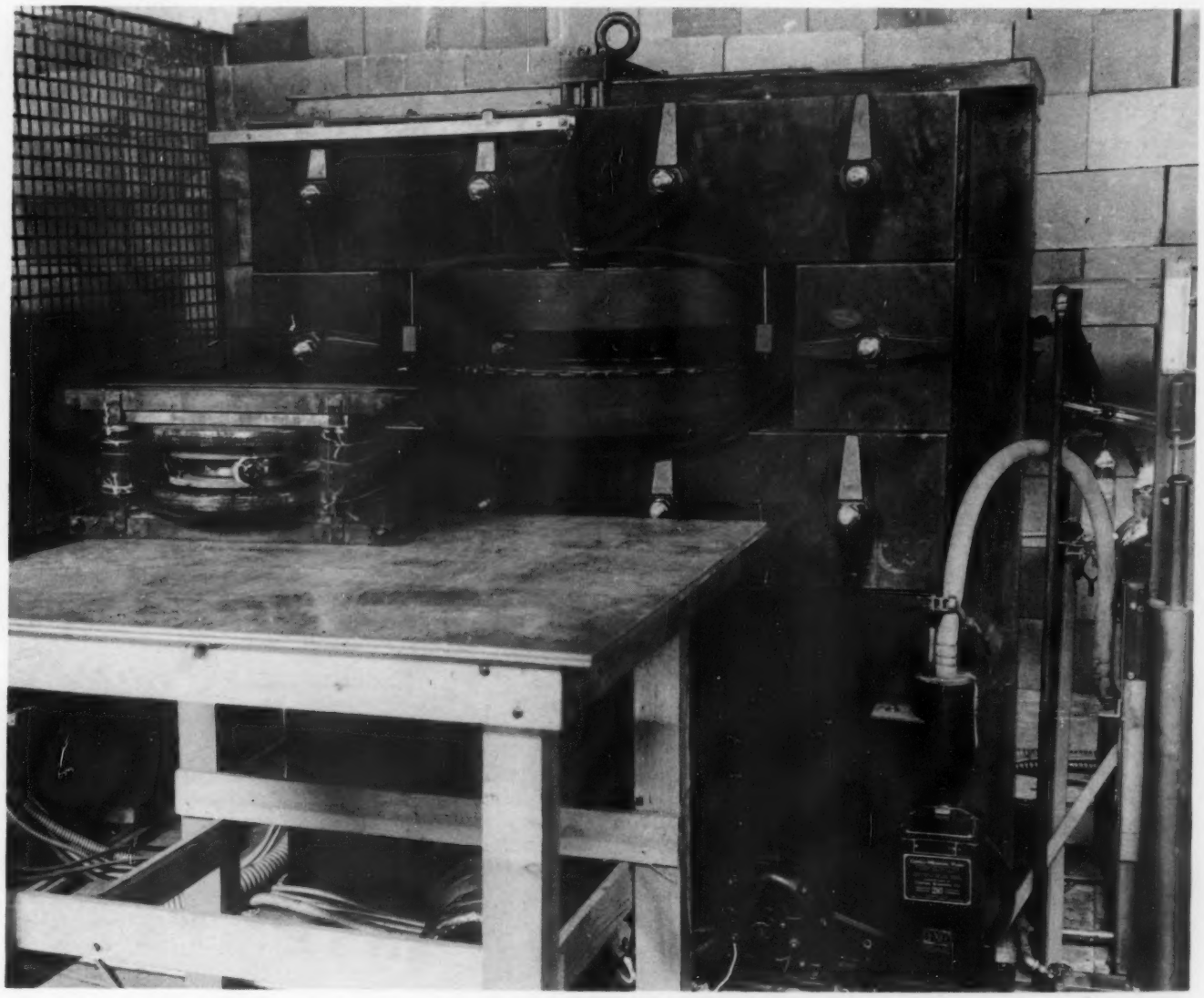
Fig. 2. Sketch of the electron path in the vacuum doughnut. The sine wave indicates the magnetic field as a function of time. Electrons are injected into the orbit at the time, A, in every cycle, and are sent against the target at the time, B.

the betatron and to provide a wall capable of stopping the electrons which are thrown out of the doughnut.

Experiments already done with the X-ray beam show that the ionization distribution produced in tissue-like material should have features advantageous to the use of the betatron for deep therapy. Other experiments have to do with nuclear disintegrations and promise to furnish an accurate voltage scale extending up to 20 million electron volts. Certain nuclear reactions have sharp thresholds at which the reactions start. These thresholds for photo-disintegration of the nucleus are being accurately determined by the use of the betatron and will establish fixed points on the voltage scale.

From the first sign of successful operation of the small betatron in our physics laboratory we have planned for and made the design for extending the betatron's energy to the region of 100 million volts, where the phenomena produced by the radiation from the betatron will resemble that found in cosmic ray observations. Electrons of this energy are capable of producing showers of X-rays and positive and negative electrons exactly as the high energy cosmic radiation produces them in the upper atmosphere. These effects should be very easily observable in the region below 100 million volts, and we expect to see some small scale cosmic ray effects at energies as low as 20 million volts.

Fig. 1. The three million volt and the 20 million volt betatrons



GLASS GETS TOUGH

NEW COMPOUNDS EXHIBIT EXTRAORDINARY PHYSICAL PROPERTIES

By LIBBEY-OWENS-FORD GLASS COMPANY

Everybody knows what happens when chilled glass is drenched with hot water, but one of the characteristics of heat-tempered plate glass is its high resistance to thermal shock. Here, for example, a glass technician is shown pouring molten lead upon a pane of heat-tempered glass that is resting on a cake of ice.

THE war has created vast and kaleidoscopic changes in the American industrial scene, with automobile manufacturers turning to the production of shells, a lipstick firm making machine gun bullets and a kitchenware plant creating parts for fighting planes. And not only is industry "changing its spots" but many essentially peace-time products have been toughened up and sent to war.

Outstanding among these domestic articles now in war regalia is glass. Ordinarily thought of as fragile, glass is proving itself to be a tough and essential part of war machines on far-flung battlefronts, on the sea and in the air.

Developed by the Libbey-Owens-Ford Glass Company, a special heat-resistant, flexible and shock-resistant plate glass, known as Tuf-flex, is being produced under government contracts for installation as the facings on the army's new 800,000,000 candlepower searchlights; for portholes and instrument dial facings in battleships and destroyers; windshields of "mosquito" torpedo boats, and as "periscope" type mirrors in army tanks.

A quarter-inch pane of this tempered plate glass will resist the impact of a two-pound steel ball dropped from a height of six feet, while ordinary plate glass breaks under a drop of less than a foot. Flexible to a remarkable degree, a three-quarter-inch pane of Tuf-flex, supported in the air by only two ends, has held the weight of a two-ton elephant without breaking. Due to a special process of tempering, Tuf-flex is very resistant to thermal shock. Tests in the laboratories have proved that the glass will withstand, while resting on a cake of ice, the thermal change created by pouring molten lead over its opposite surface.

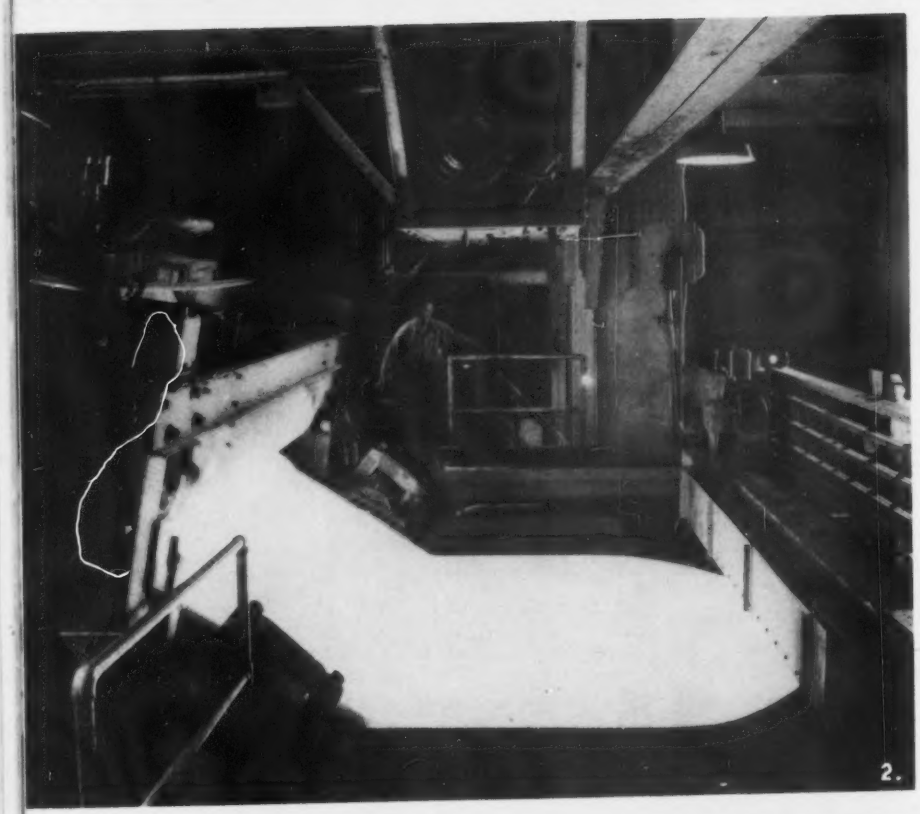
These unusual physical characteristics admirably fit Tuf-flex for its important duties as an essential part of the many and varied types of war machines in which it has been installed.

Although many years were devoted to the development of this glass, the processing of Tuf-flex today is a comparatively simple procedure and reveals but little of its long research history. It is produced by heating ordinary plate glass until it is almost plastic and then cooling it suddenly by subjecting both surfaces to jets of air. The outer surfaces, cooling more rapidly, are in a state of compression, while the inner portion of the glass is in tension or pressure in the opposite direction.

This glass is serving not only on the fighting fronts of the world, but is helping to win the war "back of the lines" by replacing vital metals in hundreds of household articles and industrial machines. For example, Tuf-flex is gaining wide use in the doors of kitchen ovens where it serves the dual purpose of replacing metal and giving the housewife a far wider range of vision into the interior of her oven without opening the door. The use of this glass is not restricted only to the stove in kitchens but is adapted to employment as sink drainboards, shelving, cabinet doors, table tops and as lids for cooking utensils. Elsewhere in the home, Tuf-flex is being used for glass shower stalls, bath- (*Continued on page 132*)

1.

1. Here is illustrated a part of the pot-casting method for producing plate glass. From the furnace is drawn a ton of white-hot glass. The clay pot containing the glass is drawn out by a huge steel claw operated by a giant overhead crane and carried to steel rollers which spread out the viscous mass into large sheets. By this method 20 pots of glass can be prepared at once, each of a different type if desired. The raw batch — sand, soda ash, lime and the other ingredients — are fed into the pots and gas flames liquefy the materials into glass by a temperature of approximately 2,700 degrees Fahrenheit. Clear and colored plate glass and opaque colored structural flat glass known as Vitrolite are produced in this manner.



2.

2. Casting. The Bicheroux or pot method of casting plate glass is used in the manufacture of plate glasses of a nature where only a relatively small amount of any one type is desired. This view shows an immense clay pot of molten glass (left) just as it has been tipped so that the white-hot contents cascade downward between great rollers which flatten out the glass. Here the glass is shown just after part of the glass had emerged from between the rollers and came to rest as a glowing orange-colored carpet on the casting table. A second later it was automatically whisked forward and into the lehrs (out of sight at the right) where temperatures are automatically and progressively lowered to properly anneal the glass. This trip through the annealing oven requires approximately 90 minutes. As the glass is released from the pot, its temperature is about 1800 degrees Fahrenheit. After annealing, the plate glass is trimmed at the edges and made ready for the grinding and polishing lines.

3.

3. The plate glass blanks are placed on slow moving tables that look like miniature flat cars. The tables, moving on tracks, go under a long battery of whirling grinders and polishers for a distance of 750 feet. First, a coarse grade of sand is fed to the grinding discs, and then gradually finer and finer sand until the top surface is ground flat and waviness has been removed. The blanks are then transferred to another 750-foot line for grinding and polishing the other surface. In the polishing process, "rouge" or iron oxide replaces sand and the giant discs, which are faced with felt, polish the glass to mirror-like brilliance.

4. Processing finished plate glass into Tuf-flex form is a relatively simple task, although it represents long research in "how to do it." The lights of glass, held vertical by tongs, are moved into the electrically heated furnace in the background and heated to a cherry red. Then a blast of cold air cools the outside surfaces more rapidly, causing a molecular change that imparts unusual strength characteristics.

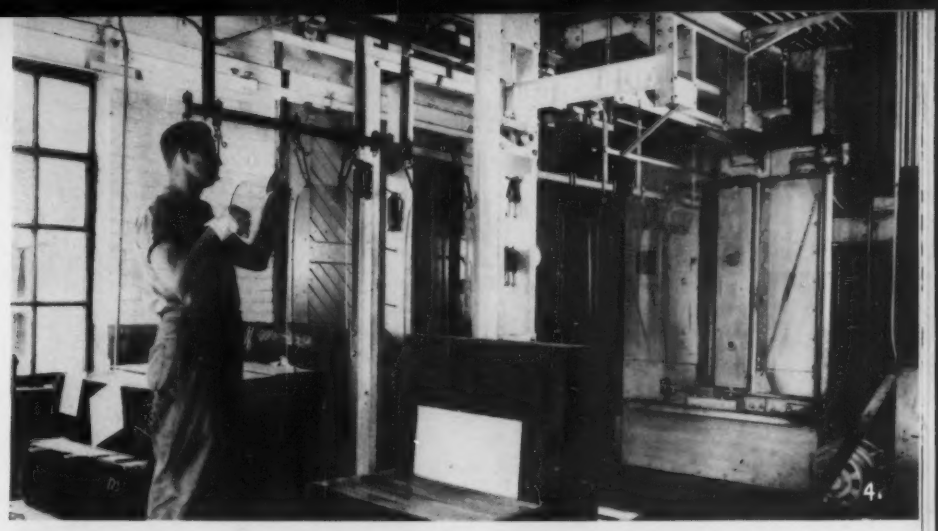
5. This view shows a suspended light or pane emerging from the furnace and moving forward to a position between two "walls" consisting of a series of pipes through which jets of air are blasted against the hot surfaces of the glass. This process, cooling the two exterior surfaces more rapidly, causes a compressive action on the outside of the glass, while the relatively warm interior of the glass is in a state of expansion. When the hard exterior surface or "skin" is punctured, the entire sheet of glass disintegrates or "explodes" simultaneously, the glass shattering into tiny and somewhat powdery pieces rather than into sharp, jagged bits as in the case of ordinary plate glass.

6. You may have difficulty in borrowing an elephant to try this test, but in the zoo at Toledo, Ohio, glass technicians placed a pane of heat-tempered glass only three-quarters inch thick on a low platform and had a three-ton elephant step upon the glass platform. The glass bent but did not break under this amazing live-weight load test.

7. Heat-tempered glass being subjected to a twenty-degree bead. When pressure is released the glass returns to its normal position.

8. Tuf-flex cannot be cut "on the job," that is, if a sheet of Tuf-flex were found to be slightly too large for the installation involved, the glass could not be cut. Punctured at any point sufficiently deep to penetrate the hard outer "skin," the entire sheet of glass shatters instantly throughout. Thus, the plate glass must be cut to exact sizes before heat-treat processing at the point of manufacture.

9. Glass Goes to Sea. An inspector examines a disc of Tuf-flex ready to be shipped to a navy yard for installation in the porthole of a United States battleship. The tempering process makes it so resistant to sudden impacts, as from ocean waves, it need be little more than half as thick as ordinary plate glass to stand all shocks.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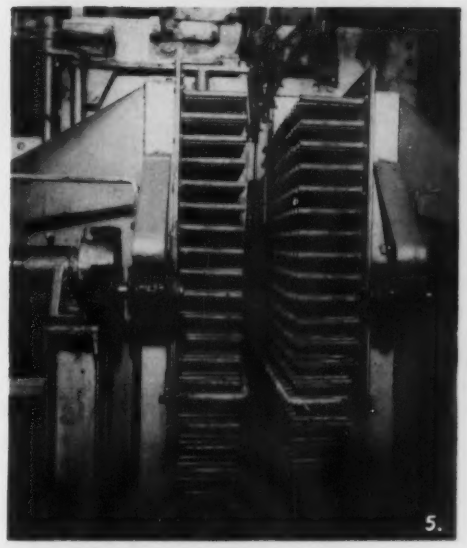
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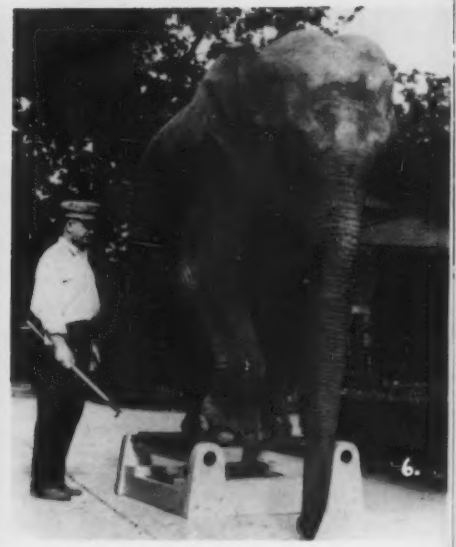
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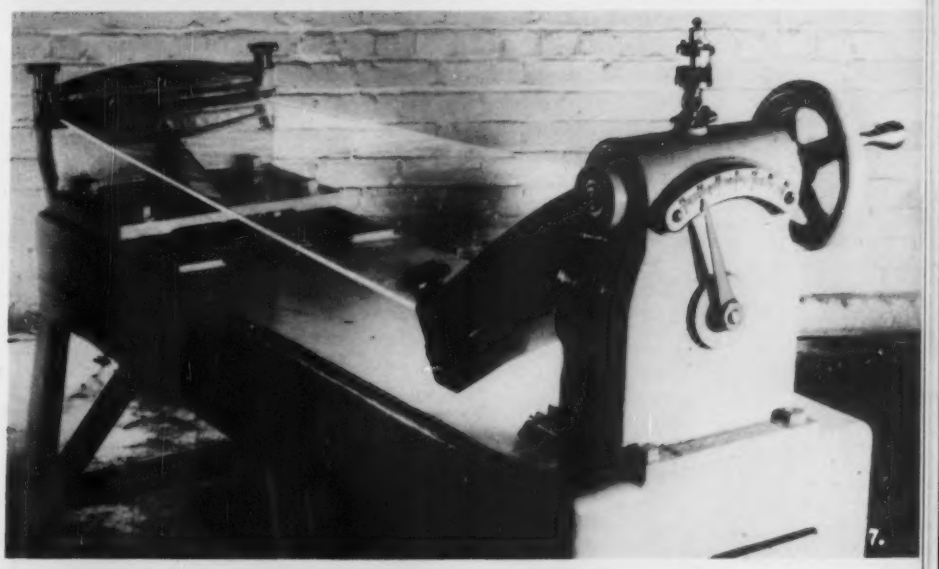
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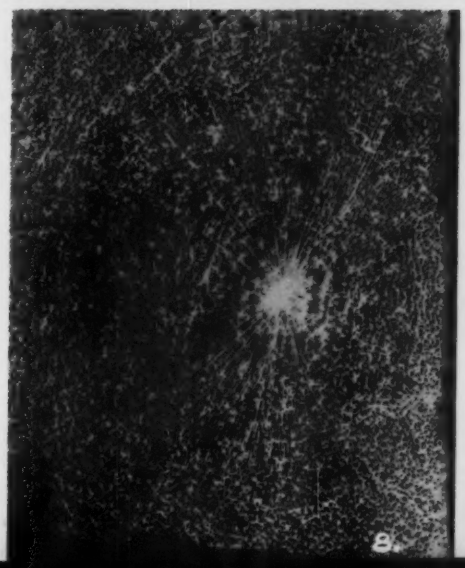

8.

9.

GLASS GETS TOUGH

(*Continued from page 129*)

room cabinet doors and shelves, and on a myriad of other "everyday" household articles.

It is taking the place of metals, too, in industry where it is of especial value in working with intense heats. An example of this is the use of Tuf-flex as heat shields for operators of cranes handling hot metals.

Another type of heat-tempered glass that is proving of value in replacing metals and other war materials is known as Vitrolux. It is made by spraying finely powdered glass of any desired color on one surface of plate glass that is to be tempered. The colored glass fuses with the plate glass during the tempering process. By careful control of the amount of powdered glass used, Vitrolux can be rendered either opaque or translucent. It has created a luminous form of architecture and decoration, particularly for street signs, certain types of store front construction and as decorative partitions and paneling in commercial and residential construction.

Another interesting glass is an opaque structural flat glass called Vitrolite. Produced in many colors, Vitrolite is ideal for store front construction, corridors, bathroom and kitchen walls, wainscoting and similar applications. Like ordinary plate glass, it is impervious to moisture, grease or the effects of most acids, except hydrofluoric, which is used to etch glass. Combined with the luminous architecture of Vitrolux, this glass adds unusual beauty to building fronts while reducing costly upkeep due to the ease with which it may be cleaned. This glass also eliminates necessity of the "annual" cleaning and painting most ordinary building materials demand. Vitrolite may be decorated by sandblasting and inlays of other colored glass, lacquers, bronze, silver or gold.

Still another type of glass being produced is one in the form of a glass-faced masonry unit. Known as Glastone, this unit is an adaptation of Vitrolite but is bonded or solidly anchored to a pre-cast block of lightweight concrete to provide the building field with its first glass faced, load bearing masonry unit. The Vitrolite facing, available in a wide range of colors, gives the architect an opportunity to create with Glastone many interesting and permanent designs.

Thermopane, a double unit insulating "window" which is playing an important role in the construction of display cabinets for perishable foods, is an interesting type of glass. Principle of this unit is the placing of two or more lights of glass together, with an air space for insulation between. The unit is then sealed around the edges with metal.

The idea leading to the present Thermopane unit came from a refrigeration engineer, C. D. Haven, who became provoked because condensation on shop windows obscured attractive displays. Haven's original double window was sealed with a material which proved not entirely practical. Four years of research brought forth the present metal to glass seal. A gruelling test of this seal was made by Rear Admiral Richard E. Byrd, U.S.N., in 1939 when he took with him to Little America several lights of triple Thermopane for windows in the expedition's laboratory. A radiogram report received after the windows had been in use for some time said in part:

"Superior to any windows I have ever seen installed in Antarctica and permit almost perfect visibility at temperatures down to at least 75 degrees below zero, with a room temperature 75 degrees inside, or a temperature gradient of 150 degrees."

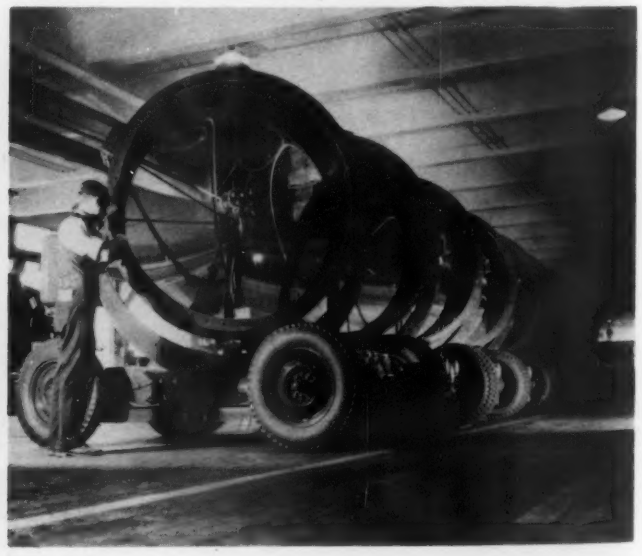
In research laboratories, Thermopane units have been subjected to unusually severe tests in which the temperature on opposite sides has been varied from 25 degrees below zero to 115 above and the humidity has been changed from dry to saturated. The metal sealed units have withstood these abnormal changes and no condensation appeared in any of the tests.

Another important contribution to the war effort has been the development of "golden" plate glass for use in high flying bombers to filter out ultraviolet rays of the sun. In stratosphere flying pilots and gun crews have been severely burned by ultraviolet rays.

Another type of heat-absorbent glass also has been developed and is proving efficient in solving problems of temperature control. This glass is used in display windows which face the sun, or in office and home or hospital windows when vision without uncomfortable sun heat is required. By absorbing the heat rays, this special glass helps to maintain lower room temperatures and, where air conditioning units are operating, enables the unit to be run with less power and at a lower cost.

***Metal-Saving Stove.** To save critical materials the "splashboard" of this stove is fitted with translucent colored glass.*

***New Specs for Army Eyes.** Heat-strengthened glass is replacing ordinary glass, which cracks with sudden temperature changes, in our new searchlights.*



A typical borehole wire installation

CONDUCTING THE WAR EFFORT

UPON THE CABLE INDUSTRY RESTS MUCH OF THE WAR'S COMMUNICATION PROBLEM

By ALAN S. MICHAELS, '44

IN modern mechanized warfare, the army travels not only, as Napoleon put it, on its stomach, but equally, if not more so, on the wings of electricity. The success of the intricate and highly complex communication system which directs and governs every phase of the war effort depends completely upon the proper electrical and physical construction of those wires and cables completing the thousands of circuits made every minute of the day. The manufacture of such cables is an art and an exact science which is the product of many years of research, and whose importance, unfortunately, has often been sadly underestimated.

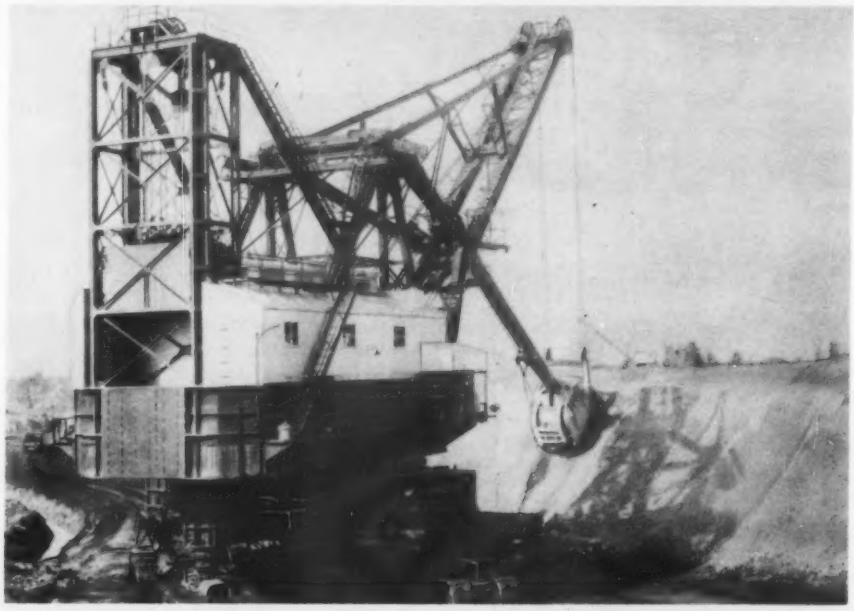
The "science" of cable manufacture is perhaps the most versatile and encompassing in all industry. Imagine, for example, that you are a construction engineer in the cable industry. You receive an order for one hundred nautical miles of submarine cable for use in the Caribbean. This cable is to contain one conductor which must be able to withstand voltages from 2 to 2.5 kilovolts with a potential drop of not more than 15 per cent.

Well, where do you start? The best place is at the bottom of the Caribbean. Maps of the ocean bottom show you that parts of the path along which the cable is to be laid is heavy mud. Others are full of razor-sharp volcanic rock. Still others are sandy, with submarine dunes shifting constantly with the currents. Temperatures vary from 80 to 33 degrees Fahrenheit. Depths range from 50 to 2,000 fathoms. There is one place where the cable must span a 50-foot chasm. Destructive marine life presents another problem that must be taken into consideration.

You analyze the problem and find that it becomes more and more complex. You must make the cable heavy enough to sink and stay put, but not so heavy that it sinks too deep into the bottom to be readily raised for repairs. It must be strong enough to support several thousand feet of its own length so that it can stand the stresses of the laying process. It must be rigid enough so as not to weave with swift ocean currents, but not so rigid that it cannot be coiled on reels small enough to carry the full length in one shipload. Its outer jacket must be water- and abrasion-resistant. It must be protected by a steel wire armor strong enough to hold up under severe conditions, but properly proportioned to the desired weight requirements. Beneath the armor there must be a rubber compound of reasonably heavy weight, yet strong enough to stand tensile and bending stresses. But such compounds usually have very poor electrical properties, and the conductor must yet be insulated from the surrounding cable by a compound of such dielectric constant, capacitance, megohm resistivity, and power factor that electrical losses are minimized. Finally, the conductor itself must

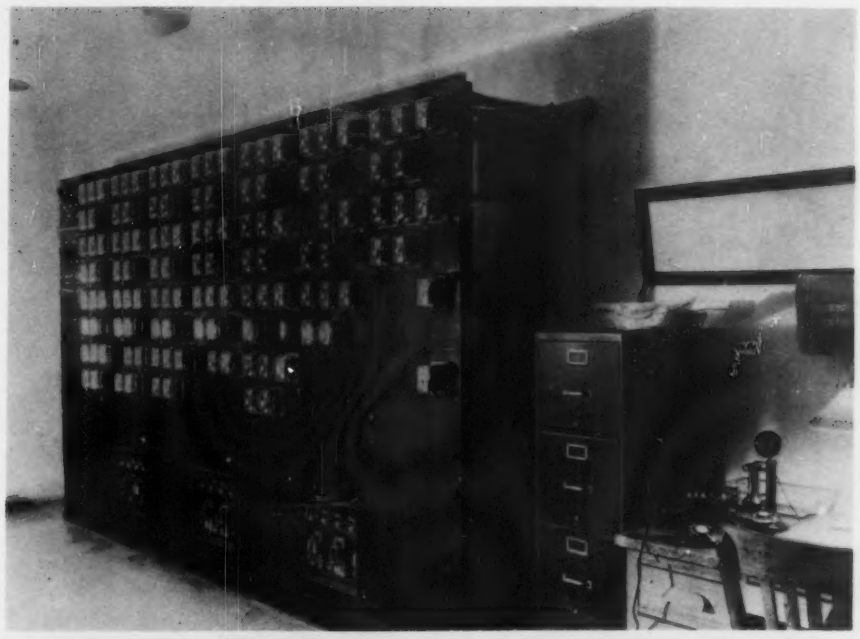
All pictures furnished by The Simplex Wire and Cable Company.

1. In wartime, cables play an especially important role in cutting and loading machinery in coal mines. . . .



2. . . . In the wiring of excavation apparatus of many types. . . .

3. . . . In welding operations of every description, such as this picture of ship construction. . . .



4. . . . In the complex signal control system of railroads; a supervisory relay control circuit panel of one of the country's larger roads. . . .

5. . . . And even in our inconspicuous automobile traffic signal circuits.

be of such proportions and structure that strength, conductivity, and heat dissipation are completely accounted for. In stranded conductors carrying alternating currents inductance between strands often produces freak effects which are too important to be overlooked.

This seemingly hopeless task — the designing of such a cable — is carried out from previous experience as well as from scientific analysis. Approximate dimensions and structure are proposed, and tests are performed on short lengths to determine whether specifications are met. Conductor and armor wire is subjected to ultimate strength analyses and to chemical tests for uniformity of its tin or zinc alloy coating respectively. Rubber is put through tests for tension, compression, electrical properties, aging, oil and water absorption, and for changes due to wide variations in temperature. Samples of completed cable are checked for uniformity and for integration between adjacent layers. Other samples are tested by imposing upon them conditions many times more severe than will actually occur in operation. The results of this detailed analysis, when properly compiled and applied, allow the engineer to make appropriate changes in his data, and to hand completed specifications over to the manufacturing department.

To prepare any cable, whether it is as complicated as the submarine cable to which we have been referring or not, requires careful coördination of every process of its manufacture. Timing is an all-important factor. When one considers for example that a unit length of heavy cable is often a mile or more; that, for insulation, two or three seconds' over- or under-curing may, and usually does, result in complete failure of a compound to comply with original specifications; and that five-thousand-odd feet of cable may contain many hundreds of pounds of a substance so rare and expensive these days as rubber, waste can hardly be tolerated. For this reason temperature, pressure, and period of vulcanization are kept as (*Continued on page 138*)

CAPACITANCE BECOMES BOSS

BEAT FREQUENCY CIRCUITS ACT AS INSPECTORS AND DETECTIVES

By C. PETER JOHNSON, JR., '45

THE beat-frequency meter is a new type of detecting and measuring device that has recently been introduced into industry. Its primary purpose is to detect small objects at large distances and to measure with extreme accuracy the dimensions of small articles. In its ability both to detect the presence of objects and to measure them it far surpasses even the electric eye, and hence is one of the most promising of measuring devices. Indeed, it has proved so highly successful that it has been accepted throughout a large part of industry as a means of sorting objects and of controlling their manufacture.

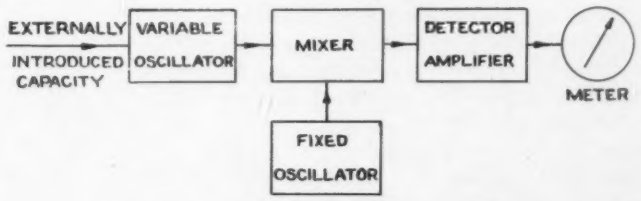
The beat-frequency meter belongs to a class of radio-frequency instruments known as the tuned-circuit or capacitance-operated group. The fundamental operation of any tuned-circuit detector is the detuning of a tuned circuit by introducing a small amount of capacity into it. If an external body is brought near the tuned or resonant circuit, the capacitance of the circuit is increased. As a result, the circuit is detuned and a great change in its electrical properties takes place. The impedance, or effective resistance, of the resonant circuit drops from an extremely high value to a very low one, and the voltage and power developed by the tuned circuit are consequently greatly decreased. Almost any of the changes in the circuit properties can be used as a means of detecting the outside body. If the tuned circuit is in the plate circuit of a radio-frequency oscillator, the rise in plate current accompanying the loss of impedance of the tuned circuit when it is detuned can be made to operate a relay. An amplifier, moreover, can be operated by the voltage developed across the resonant circuit in the plate circuit of the oscillator. The decrease in resonant-circuit voltage accompanying detuning decreases the bias on the amplifier and thus increases its plate current, which can then operate a relay.

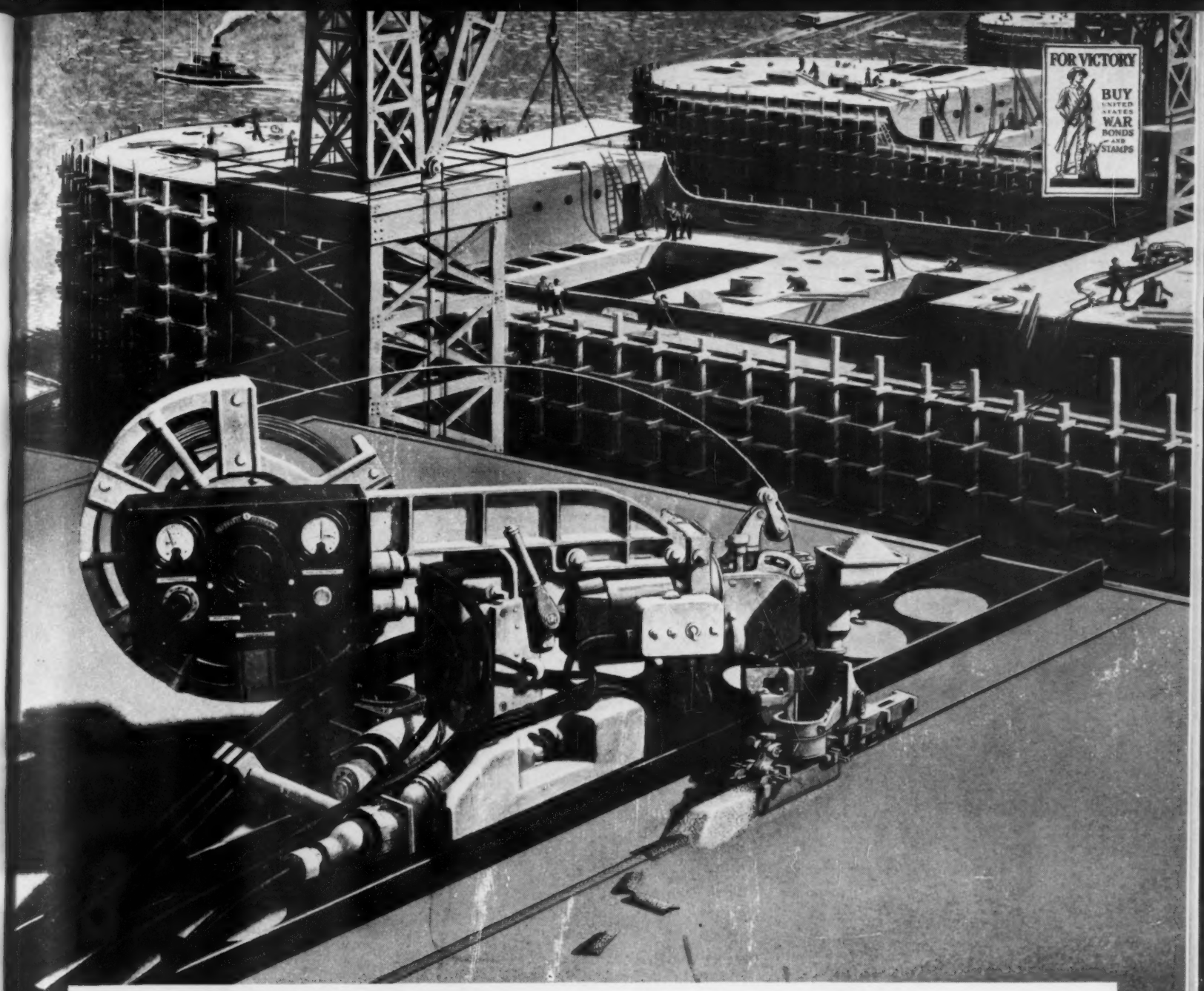
The beat-frequency meter contains two radio-frequency oscillators which are tuned almost exactly to the same frequency. The outputs of the two oscillators are mixed in a frequency converter vacuum tube, and the frequency difference, or beat frequency, of the two oscillators emerges. After passing through a tuned circuit, the beat-frequency current is used to bias another vacuum tube, the plate current of which passes through a relay. A small metal disk or piece of wire is attached to the tuned circuit of one of the oscillators. When an external body approaches the disk or piece of wire, capacity is introduced into the circuit of the oscillator, and the oscillator frequency decreases. Since the two oscillators were originally tuned almost exactly to the same frequency, there is a large variation in the beat frequency, or frequency difference, of the oscillators. The tuned circuit through which the beat frequency passes is no longer tuned to the beat frequency, and the voltage developed across the resonant circuit, which biases the amplifier, decreases. As a result, the amplifier plate current rises and operates a relay. Fig. 2 shows what happens to the outputs of the two oscillators.

The meter is an exceedingly sensitive instrument. Theoretically the only limit to its sensitivity is the stability of the oscillators, and by the use of quartz crystals and temperature-compensating devices this stability can be increased almost indefinitely. In practice, moreover, the meter is far more sensitive than is necessary for its applications. It is quite easy to make one so sensitive that a slight motion of one's hand can be detected at forty feet. Instruments have been made that can measure and sort articles far better than the most accurate mechanical tool. Furthermore, the sorting is a very rapid one. Within a fraction of a second the beat-frequency meter will register the deviation of an object from standard dimensions. Practically the only fault accompanying its many uses is that it is sometimes too sensitive, too easily influenced by small variations. However, its widespread adoption in industry shows that this fault is of no actual importance.

As one would suspect because of the marvelous properties of the beat-frequency meter, the instrument has a myriad of uses. However, two of its most important applications are sorting small objects and controlling their manufacture. Although it is readily adapted to controlling the manufacture of articles, purely mechanical limitations in the producing machine prevent the complete realization of the tremendous accuracy of the meter. Therefore its most important use lies in sorting objects. If a very small clearance is required between two kinds of articles, the beat-frequency meter can sort the two kinds of objects and match those that will best fit together. Furthermore, the sorting operation of the instrument is so rapid that even objects having large tolerances of dimensions can be profitably sorted. If an endless belt carrying small articles is run beneath the meter, the objects (*Continued on page 146*)

Fig. 1. Block diagram for a typical beat-frequency meter





MAKING ONE-PIECE SUITS FOR *SHIPS!*

THERE'S NEWS on America's ship ways today . . . an amazing machine that unites steel plates without noise, fuss, sparks or visible arc! A process that is helping to construct those marvels of speed, strength, safety, and carrying capacity . . . "all-welded" ships!

This process . . . known as "Unionmelt" Welding . . . joins steel plates of any commercial thickness as much as 20 *times faster* than any other similarly applicable method! And it produces uniformly high-quality welds!

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The process is completely automatic. Special apparatus feeds the "Unionmelt," the welding rod, and the electric current. Speed and current values are adjusted by an operator.

"Unionmelt" welding is also speeding up the construction of fighting tanks and chemical tanks . . . artillery mounts and aircraft parts . . . pressure vessels and locomotive boilers . . . pipe and pipe lines . . . and all kinds of heavy mechanical equipment.

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CONDUCTING THE WAR EFFORT

(*Continued from page 135*)

near the precise values as is industrially feasible. The rate at which the cable travels within and between various processing machines must be controlled to prevent undue stress from being set up at any point. Accidental breakage along the production line is a nuisance which holds up work and breaks routine often for long periods of time.

But perhaps the best way to visualize the intricacies of manufacture is to follow the construction of our special submarine cable from start to finish.

The cross-section of this cable will, according to the engineering and development department, look like that shown in Fig. 1. It has been decided that a stranded tinned-copper conductor will be used. For maximum conductivity, especially when cable lengths are long, annealed copper is used. (In the case of heavily armored submarine cable with which we are at present concerned, conductor strength is secondary to conductivity since the outer steel armor will actually carry the largest physical load.) This wire, shipped to the plant in large coils, is transferred to reels, run at high speed first through an acid vat, then through a cauldron of molten tin, and finally wound on bobbins.

These bobbins, in turn, are placed in the rotating cage of the stranding machine. This device twists several strands of wire around one which forms the core. As the core moves through the conical cage, the latter rotates, twining the other strands uniformly around the center wire. The stranded (*Continued on page 140*)

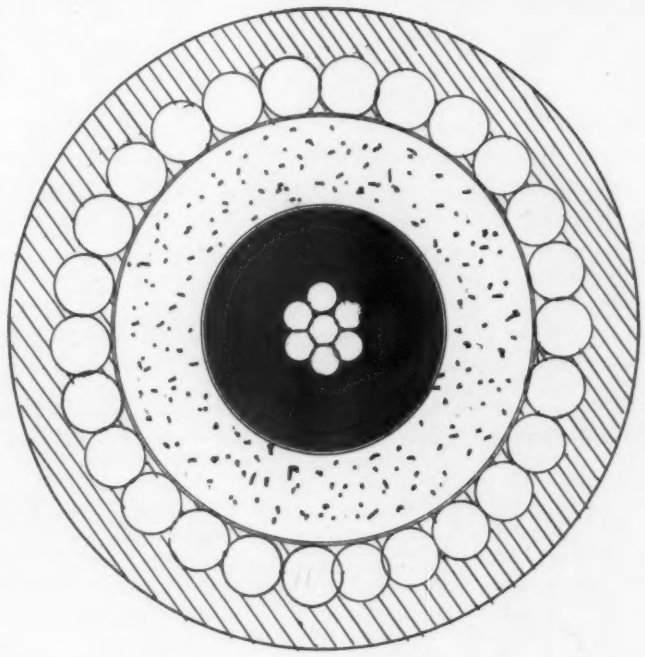


Figure 1

Battle wagons have glass ears . . .

SOMEWHERE on the tough hide of U. S. warships are mounted what look like inverted glass mixing bowls.

These are the radio lead-in insulators, the "ears" through which the battle wagons get their orders. They are made of Pyrex brand electrical glass, as are the insulators in the ships' antenna, because the service requires the best and most dependable materials available.

Today, with metals scarce, the raw materials for glass are fairly plentiful. And glass is being put to work at many urgent tasks. Planes, tanks, ships, trains, for example—all use some contribution of Corning research in glass. The giant dairy industry, faced with a metal piping shortage, is now working with special glass piping recently developed at Corning. In chemical, food, and explosives plants, glass piping and glass pumps are handling everything from soup to HCL.

Years ago glass was regarded as a fragile, decorative, costly material with limited applications. Now Corning makes glassware that has kicked old barriers out the window. It's tough and strong, resistant to chemical attack and thermal shocks, widely varied in shape and size, reasonable in cost, and accurate to tolerances comparing favorably with metals. Today's engineers are discovering that they can put glass to practical uses which in the past were labeled, "impossible". For tomorrow's engineers, glass is the material of unlimited possibilities. Industrial Division, Corning Glass Works, Corning, New York.

CORNING
means
Research in Glass

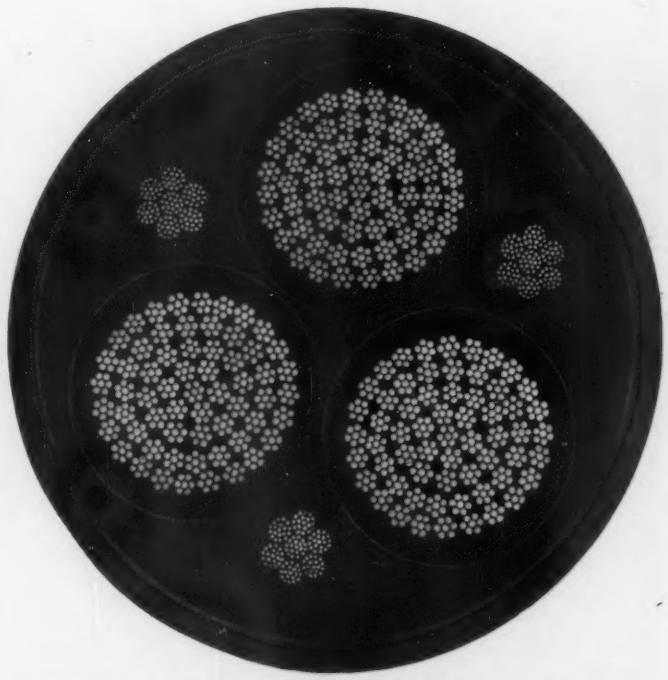
CONDUCTING THE WAR EFFORT

(*Continued from page 138*)

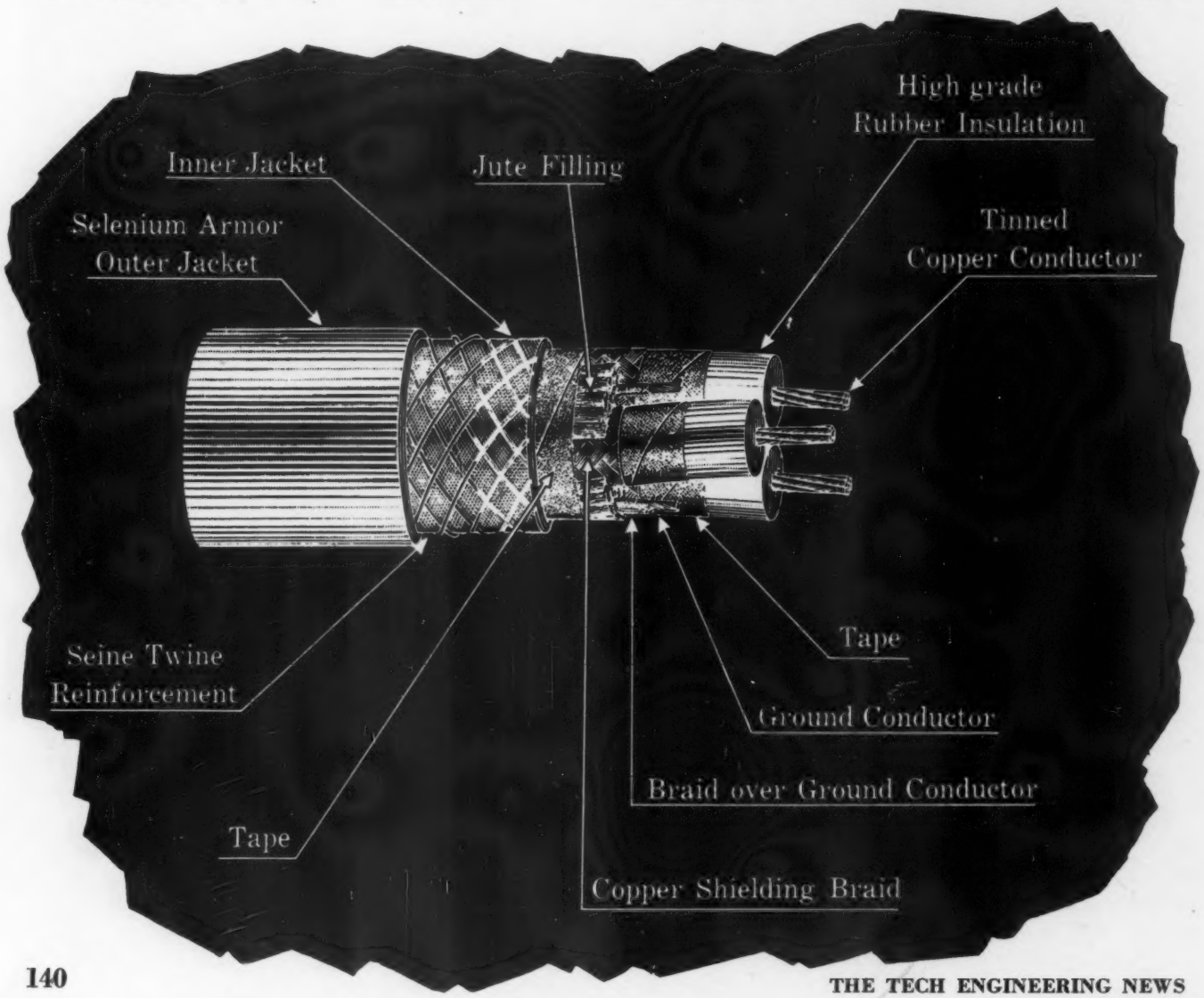
conductor is then coiled on reels to await the first step in its insulation.

In the milling department crude rubber stock is mixed with many other substances on a machine very much like a tremendous clothes wringer. Two rolls rotating at different relative speeds compress and shear the rubber and other materials so that they are intimately mixed. The temperature of the compound being milled is controlled by passing steam or cold water through the rolls. After the milling operation is complete, the uncured compound is removed from the rolls in a single strip about four inches wide, dusted with talc, and collected in deep pans.

At this point, both the wire, and the rubber which has a consistency similar to that of chewing gum, go to the insulator (Fig. 2), a machine operating very much like a meat-grinder. As the wire passes through a steam-heated steel block, the rubber stock, fed in in strip form, is forced through a ring-shaped die surrounding the conductor. As the wire moves out of the machine, the rubber is deposited upon the wire in a smooth annular layer of the desired thickness. The conductor with its first jacket is coiled into a large, round, flat pan filled with talc to prevent sticking, (*Continued on page 142*)

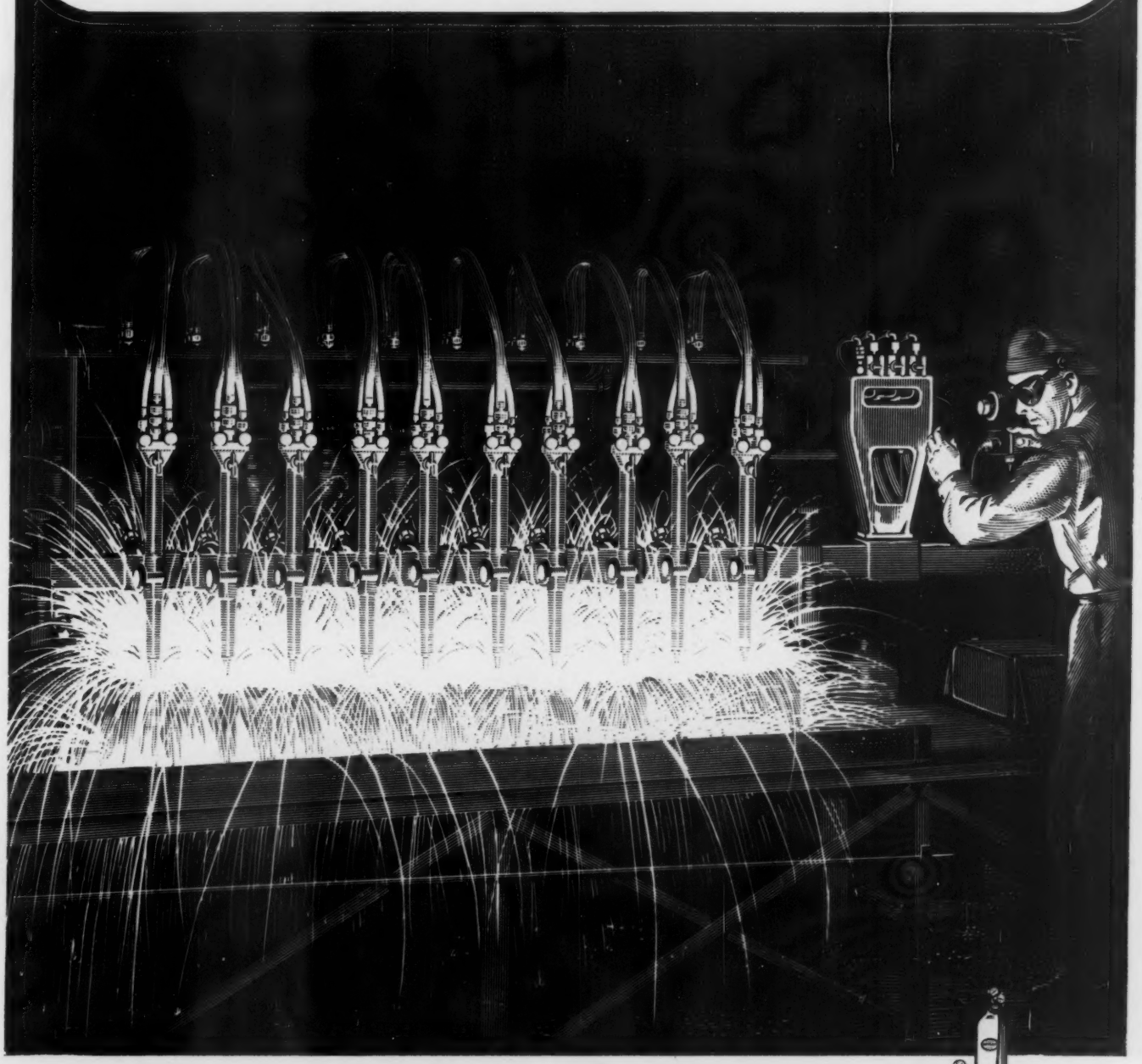


End view of the three-conductor cable shown above



Construction of a heavy-duty, flexible three-conductor cable. Such a cable would be used for surface operations where operating conditions are particularly severe.

A WEEK'S WORK EVERY DAY



TUBULAR headers now race off the production line at Combustion Engineering Company's Chattanooga, Tenn. plant at the unprecedented rate of 100 a day — with the aid of this Airco 10 cutting torch Oxygraph. Compared to the 19 a day formerly produced, it's practically a week's work every day. This Airco oxyacetylene cutting machine is making metal-working history — never before was such an elaborate multiple torch arrangement deemed practicable. Yet, as perfected by Airco, every beneficial feature of flame cutting is retained. Steel is accurately cut to the desired shape with amazing speed. And there is no time out for sharpening or regrinding.

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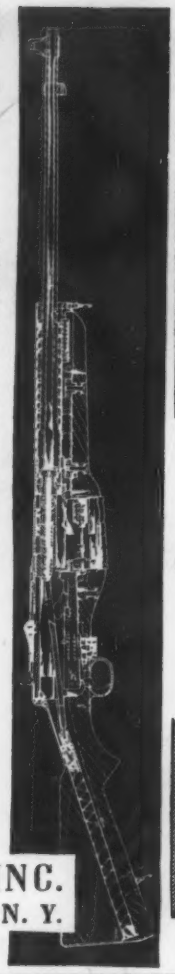

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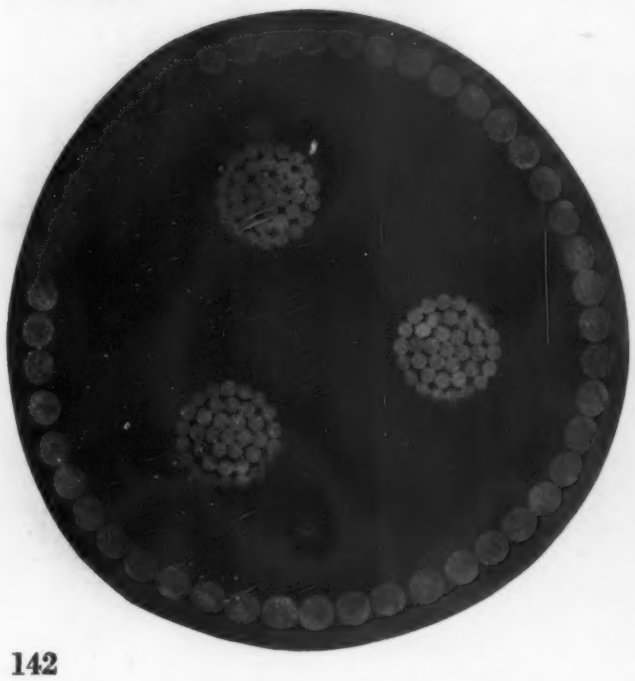
CONDUCTING THE WAR EFFORT

(*Continued from page 140*)

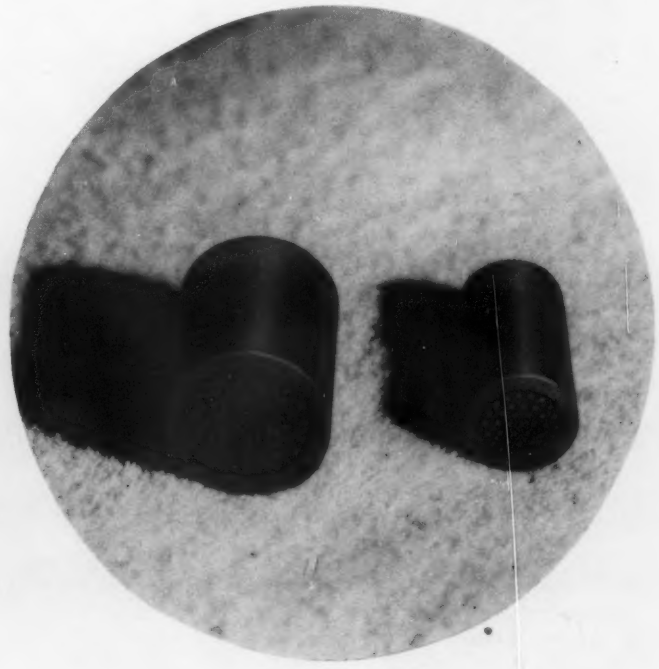
and is shipped to the curing ovens where the compound is vulcanized under proper conditions of temperature and pressure for a prescribed period of time.

(*Continued on page 144*)

Cross-section of a three-conductor, 500,000 circular mil shielded submarine cable designed to carry 150,000 volts.



Compactness of cable structure is often a necessity. Note how the use of a thin, strong, nearly pure rubber conductor insulation has reduced the cable diameter. Both samples contain the same number of conductors, yet the smaller has better electrical and physical properties.



Prepare for post-war reconstruction—

learn to "know your bearings" now

A heavy part of the burden of world reconstruction following the United Nations' victory in the war will have to be borne by graduate engineers, now in school.

Revolutionary advancements in machines of all kinds will be the order of the day and, among other things, you'll have to know your bearings in order to be able to hold your own when competition gets tough.

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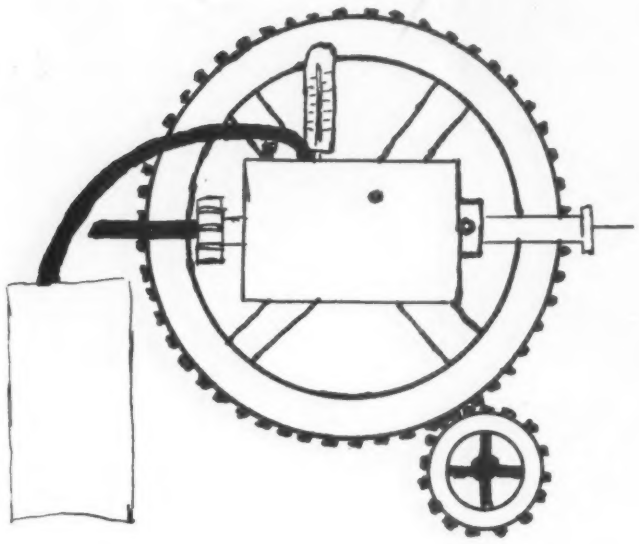
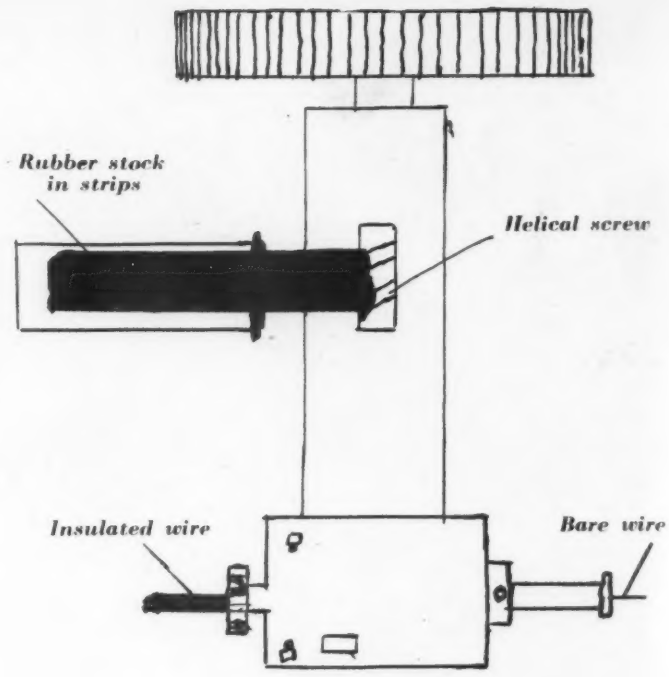
CONDUCTING THE WAR EFFORT

(*Continued from page 142*)



Front View

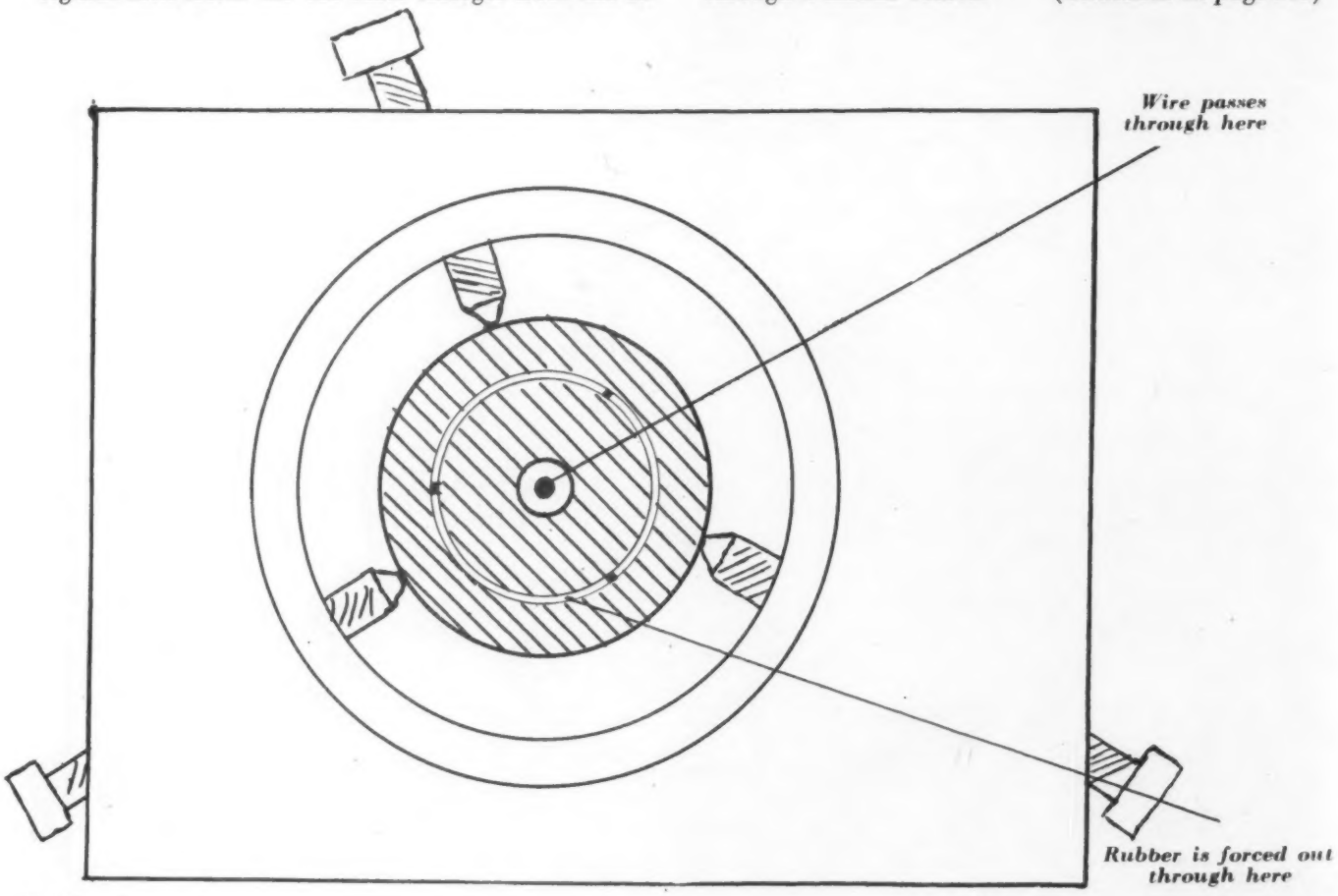


Top View

Our cable now has its preliminary insulation — a strong rubber compound of excellent electrical characteristics. It is now covered with a layer of rubberized tape to protect it from the next insulation layer.

As we move along the line, we see the cable enter an insulating machine similar to but larger than the previous one. The second compound is deposited upon the taped cable in a layer perhaps one-quarter to three-eighths inch thick. As the cable emerges from this insulator it is wound with tape and coiled on a large drum. This drum is rolled into other curing ovens, and after vulcanization, the cable is ready for the armoring process.

The armoring machine works on a principle exactly like that used for stranding the original conductor, but is on a much larger scale. The taped insulated cable, which is now one or two inches in diameter, passes through a similar conical (*Continued on page 148*)



HE SPECIALIZES IN "BIG STUFF."
L. A. Kilgore has been designing electric generators, rectifiers, and motors ever since he joined Westinghouse . . . but his 40,000 h.p. Wright Field wind-tunnel motor tops them all. Kilgore received his E. E. at the University of Nebraska and his M.S. at the University of Pittsburgh.

The hurricane that shapes an eagle's wings.

THE LIGHTNING SPEED of the modern warplane has brought a lot of headaches to aircraft designers.

Wind-tunnels, the "proving grounds" of aviation, were satisfactory for studying the performance of the lighter, slower planes of yesterday. But they were not adequate for today's fighter planes . . . with top speeds of *over 400 miles per hour.*

To investigate the terrific forces at work at these high speeds, the U. S. Army demanded a wind-tunnel that would produce a tornado many times greater than Nature's wildest gale.

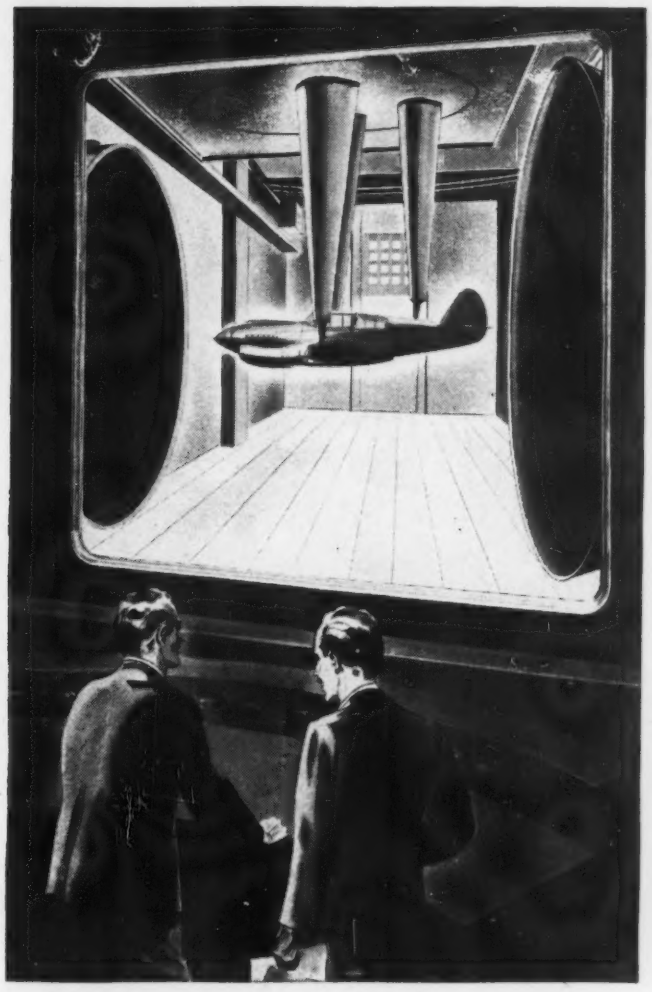
Army officials asked Westinghouse to take over the job of *building the electric motor* to drive the fans in this tunnel.

The two fans were to be truly colossal . . . 40 feet across, with a combined weight of nearly 150 tons. They were to be mounted on a 16-inch solid steel shaft, 120 feet long. Merely starting this great mass in motion, with minimum disturbance to the power system, was the toughest kind of engineering problem.

To complicate the problem further, a wide range of air speeds is required for wind-tunnel testing. And at each air speed the motor speed must be held constant, regardless of fluctuations in the electric power lines.

L. A. Kilgore . . . in collaboration with J. C. Fink . . . tackled the problem. In twelve months these Westinghouse engineers designed and supervised the construction and installation of a 40,000 hp wound-rotor induction motor . . . world's largest of its kind . . . an installation that met every Army requirement.

That 40,000 horse power motor . . . a direct result of Westinghouse "know how" . . . is now in service in the new $2,500,000 wind-tunnel at Wright Field. Large airplane models and actual-size motors, with whirling propellers, are tested and studied in its 400-mile-an-hour windstream.



• • •

Kilgore and Fink have given vital aid to winning the war . . . for they have helped to make it possible for Army experts to learn many new facts about plane performance and plane design, facts of utmost importance in gaining and maintaining air supremacy over the Axis.

Today the need for engineers is very great. Of the 300 young engineering graduates who joined Westinghouse last spring, many are already showing great promise in engineering.

Westinghouse looks to the Class of '43 for its future scientists and engineers.

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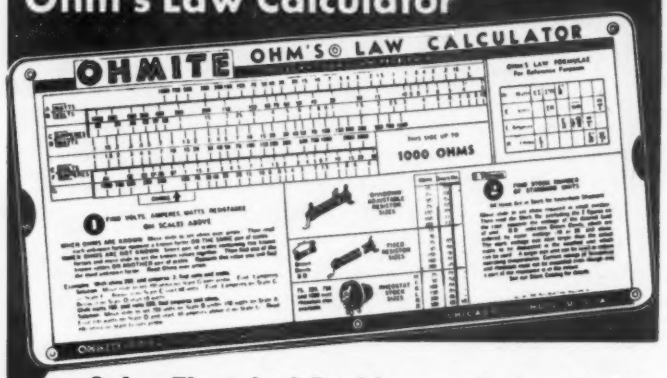

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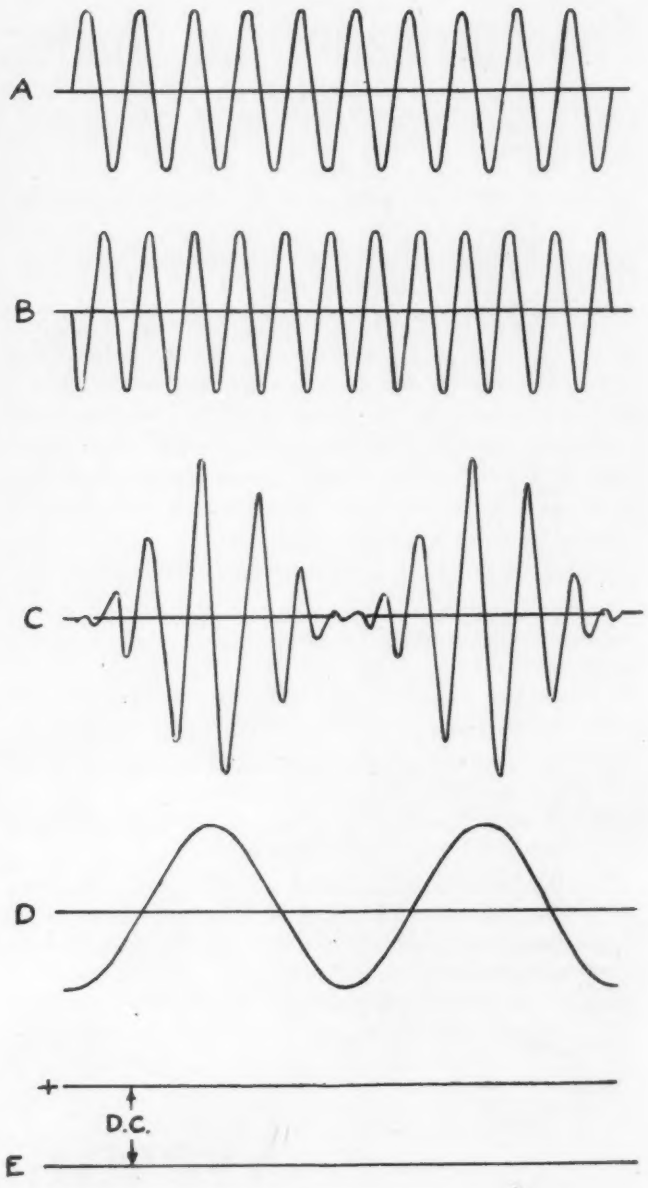
CAPACITANCE BECOMES BOSS

(Continued from page 136)

are rapidly sorted into groups of articles having the same dimensions, and at the same time undersize or oversize articles are rejected. Moreover, it is frequently used for counting the number of articles passing off an assembly line. Its great advantages over the electric eye for this use are that the objects do not have to follow a set path and that they can be counted and sorted simultaneously.

The beat-frequency meter is also used for many other purposes. In stores it is frequently used for displays to attract the customers' attention, for when a person walks near, a relay can be made to close and

Fig. 2. (a) The output of the fixed-frequency oscillator. (b) The output of the variable-frequency oscillator. (c) The mixed wave of the two oscillators produced in the frequency converter. (d) The voltage developed across the beat-frequency tuned circuit. (e) The final output after detection and amplification.



operate a demonstration. Furthermore, it is frequently used for detecting unauthorized entry into a building because it can easily detect the presence of a person. The beat-frequency meter cannot be evaded or put out of order by an intruder because it can be completely concealed, even in a wall, and cannot be approached from any direction without being operated.

Because the beat-frequency meter is non-directional, it can count objects passing in all directions. Its ultra-sensitivity to the human body makes it useful for store displays, burglar detection, and, in general, for counting people passing it, even if other large objects are moving around. The beat-frequency detector could thus be readily used in an industrial plant to count personnel and to detect any intrusion.

The cost of the instrument is, unfortunately, extremely high. However, the reason for the great cost is not the cost of production but the extensive amount of research necessary for perfecting the meter and modifying it for its various applications. The cost of the parts in the meter is a small fraction of the market price. Its circuit is actually very simple. Two oscillator tubes, one mixer tube, and one amplifier are all of the vacuum tubes required for a simple installation. The construction is so simple that even someone unfamiliar with radio could construct it. In spite of the great cost of the meter, it is being widely used in industry today, for the service that it performs far outweighs its cost. Indeed, if the apparently great demand continues to increase, it is almost certain that the cost will drop to a fraction of its present price.

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FOR Victory AND AFTER

★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Our research to maintain and improve the quality of Simplex insulated wires and cables, under restrictions designed to save critical materials, is getting results that mean better insulated conductors for commercial use after the war.

Simplex Wire & Cable Co.
79 Sidney Street, Cambridge, Mass.

CONDUCTING THE WAR EFFORT

(Continued from page 144)

cage carrying several reels of steel armor wire one-quarter of an inch in diameter. This wire is laid tightly and uniformly over the entire cable, and then bound with twine.

Over the armor are placed two or three layers of jute. The jute is then impregnated with an asphaltic compound which renders this outside jacket impervious to moisture. The cable is now ready for shipment.

Since our order is to be shipped in a single length, sections are spliced together, the individual armor wires welded to one another, and joints waterproofed with rubber. The completed cable is then marked with a tally at every nautical mile, and coiled into railroad Gondola Cars, so-called because of their shape. From here our cable goes to its destination — the ocean floor.

This is but one phase of the task before the cable industry today. The manufacture of high tension, underground, telephone, telegraph, radio, building, and aircraft wires and cables, as well as field wire and multi-conductor or coaxial cables are but a few of the many construction problems facing the industry. Each type for each purpose demands special characteristics often unlike those of any other.

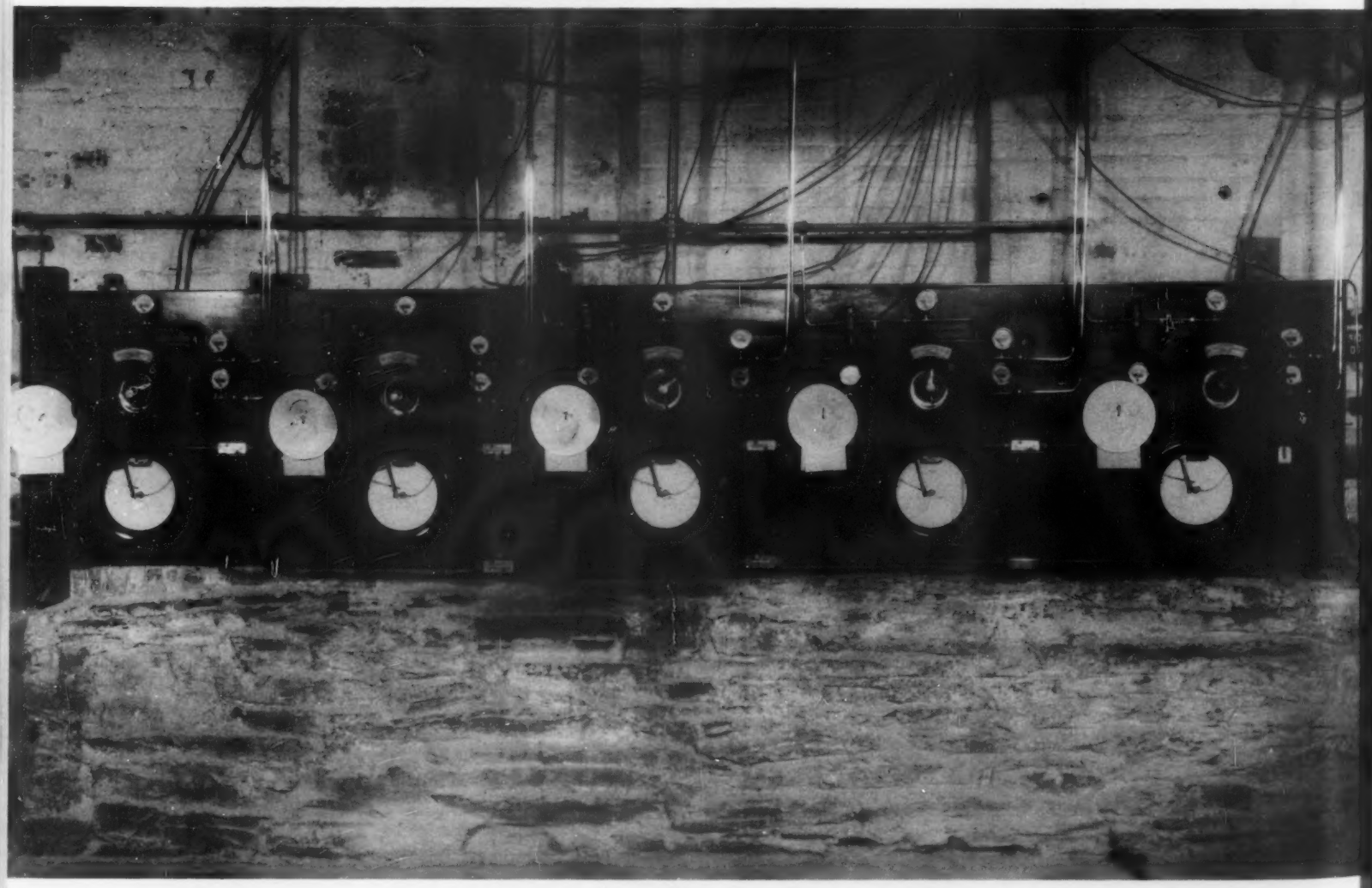
And wartime shortages are complicating manufacturing processes more and more. Scarcity of rubber has necessitated cutting down the rubber content of many insulation compounds, and to do so without much sacrifice of strength is almost an impossibility.

With the advent of synthetic rubber, new compounds have had to be devised to replace those with the natural substance as a base. This is by no means an easy task, and fortunes are being spent on research along this particular line.

But research has resulted in some interesting and fortunate discoveries. Plastics of the polyvinyl resin type, for example, have been found to possess physical and electrical properties ideal for cable insulation, and others are splendid for use in coaxial cables. Although rubber is often essential, in many smaller cables plastics are being employed with success. The brilliant colors that can be imparted to synthetic resins prove very helpful in distinguishing between conductors in multi-conductor cables.

Yet regardless of shortages, production must continue whether new developments occur or not. The military demands made upon the cable industry rival those of the aircraft and automotive trades. Thousands upon thousands of feet of wire must be processed every day to keep up with the extraordinary requirements of the emergency. The industry is doing a splendid job of fulfilling these requirements. It is valiantly helping to "conduct the war effort" — in more ways than one!

Vulcanizing temperatures must be determined accurately; a temperature control panel operating several of the vulcanizers used for curing rubber insulation.



The wheel that cuts tank armor like a sharp knife slices bread!

When steel men made tank armor that could withstand anti-tank fire, they put our army one up on the battlefield. But they posed a new problem in tank construction. Precision cutting of the armor plate is necessary at many places to insure contact for welding. But because of its toughness, ordinary mechanical cutting methods wouldn't do. What was the answer? With Carborundum Brand Cutting-Off Wheels, the 1-1/8" armor plate is now sliced like you'd slice a loaf of bread. And so accurately that mating parts fit perfectly.

These abrasive wheels have revolutionized cutting-off methods. Often of extreme thinness, they even perform such delicate operations as slotting the points of fountain pens! Today Carborundum-made Cutting-Off Wheels are used to cut plastics, glass, brick, tile, steel and non-ferrous metals in plate and bar stock ...faster, more safely, and more economically. In most cases further finishing is unnecessary.

America's war program has thrown a new spotlight on the vital role which abrasives play in industry. This role is one which Carborundum "know-how" and skill have helped to create. When you take your place in industry, you'll find these same facilities ready and able to render an invaluable service. The Carborundum Company, Niagara Falls, New York.

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G-E Campus News

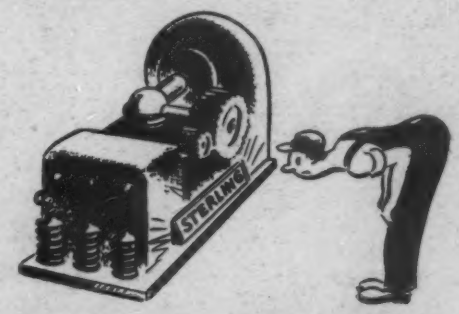
GIRLS, GIRLS, GIRLS

INASMUCH as only one-third of the 12,000 engineers who will graduate in 1943 will be available for private industry, General Electric is hiring young college women to do work formerly done by male engineers.

Forty-four "test women" are on the job now, and others will report each week until the quota (150) is reached. The girls will make computations, chart graphs, and calibrate fine instruments for use in the machine-tool industry.

Miss Virginia Frey (U. of Michigan), one of the 12 women in the country who received engineering degrees this year, is the only graduate engineer in the group. However, each of the others has majored in either mathematics or physics and has received training in both.

Although no one expects these girls to become full-fledged engineers, most of them will be given the Company's famous "test" course.



HI-YO, SILVER!

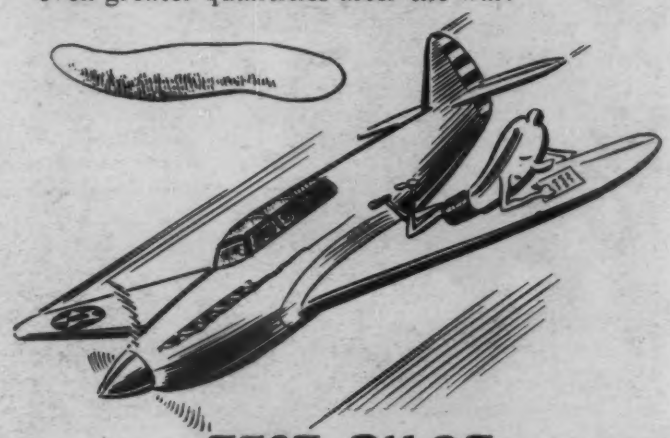
BROTHER, can you spare a dime?

Manufacturers don't really need it yet, but they are using more and more silver as other metals become increasingly difficult to get. G-E engineers, for example, are using silver in the manufacture of electric apparatus in order to conserve tin, copper, and other scarce materials.

There is now at least a little of the precious metal in almost every motor, generator, transformer, and other piece of equipment built by General Electric for the war.

In many cases the use of silver adds to the cost—a consideration secondary to production at present. Here its use is probably temporary.

But in current-carrying contacts and in brazing alloys, the use of silver results in an improvement in quality sufficient to justify the greater cost. For these purposes, silver will very likely be used in even greater quantities after the war.



TEST PILOT

THE versatile electronic tube has now become somewhat of a test pilot. On test flights, it goes along and writes a complete record of the strains on certain structural parts of the plane as it dives and twists and streaks across the sky.

When a fighter plane goes into a power dive at 500 miles an hour, for example, it has to withstand terrific strains. How great a strain is a vital question to the designer, who wants to know whether he can reduce the weight of the plane to give it greater speed.

Here's how the electronic tube helps furnish the answer to that question: strain gages measure minute changes in dimensions, converting them into tiny electric impulses which electronic tubes amplify sufficiently to drive a highly sensitive oscillograph galvanometer; the galvanometer makes a permanent record of the impulses on a photographic film. *General Electric Company, Schenectady, N. Y.*

GENERAL ELECTRIC

963-40-211

The Murray Printing Company
Kendall Square, Cambridge

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